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explanations are given for the flash spectrum. The first is the original idea of YOUNG'S,—that the chromospheric spectrum is merely the flashing out of the reversing layer, the differences of intensities being easily explainable by the different heights to which the layers of the different vapors extend above the Sun's surface. The prominence of "enhanced" lines in the flash spectrum does not seem to be quite as pronounced, from the above investigations, as LOCKYER would have us believe, and there seems, therefore, no solid foundation for the idea that the flash spectrum is at a higher temperature than that of the Fraunhofer spectrum, even if it is farther away than the "reversing layer" from the hot Sun towards the cold of interstellar space. The difficulties in the way of accepting the explanation of JULIUS, as given in the *Astrophysical Journal* for February, 1902, are that we so far have been able to find in the laboratory anomalous dispersion for only one metal, sodium, (although this does not say it may not be found for others); that no photographs have shown the doubling of the lines in the flash spectrum, except those of the Dutch party at the Sumatra eclipse, and that the doubling, if seen, could be so much more easily explained from the lack of perfect focus.

Taking all things into consideration, it seems much easier to explain the flash spectrum, as did Professor YOUNG, as a reversal of the Fraunhofer spectrum.

COLUMBIA UNIVERSITY, May 15, 1902.

SOME NEW ASTRONOMICAL INSTRUMENTS.

By FRANK SCHLESINGER.

I. THE REGISTERING MICROMETER.—The greatest obstacle in the way of more accurate determinations of Right Ascensions is the observer's personal equation, which causes him to estimate the time of a star's transit always too early or always too late. Were the personal equation constant for each observer for a reasonably long period, things would not be so bad; but it has been known to vary in the course of a single night, besides depending upon the brightness of the observed object, and even upon the steadiness of the atmosphere. REPSOLD, the head of the famous firm of instrument-makers of that name, has constructed an instrument, called the registering micrometer, which is intended to do away entirely with personal equation. Instead of the ordinary reticule seen in the eye-piece of a transit instrument, the registering micrometer has a single movable thread, which the observer sets upon the star as soon as it appears; and he keeps the image constantly bisected (during the minute or so that it takes the star to traverse the field) by steadily turning the screw to which the thread is attached. This screw is so constructed that it automatically records a signal upon a chronograph sheet every time it completes a turn, or even more often, if desired.

This micrometer has been tested by Dr. Albrecht and three others of the staff of the Potsdam Geodetic Institute. The differences of personal equation between each pair of these observers were first determined with the ordinary reticule and then with the new micrometer, with these results:—

DIFFERENCES OF PERSONAL EQUATIONS.

			With Ordinary Reticule.	With Registering Micrometer.
Albrecht	*minus*	Borass	—0^s.108	—0^s.004
Albrecht	"	Galle	—0.314	—0.035
Albrecht	"	Schnauder	—0.184	—0.027
Borass	"	Galle	—0.225	+0.013
Borass	"	Schnauder	—0.086	—0.023
Galle	"	Schnauder	+0.109	—0.006

It will thus be seen that the personal equation is gotten rid of, or at least is nearly the same for all observers. Dr. Albrecht also finds that the instrumental constants (collimation, flexure, etc.) can be more accurately determined with the new micrometer. In conjunction with Dr. Borass he has determined the difference of longitude between Potsdam and Bucharest, and between Potsdam and the Poulkova Observatory. The results show surprisingly small probable errors.

A still further improvement has been made by providing the micrometer with clockwork to move the thread across the field. As the rates with which stars apparently move are different in various parts of the sky (those nearest the equator moving fastest), the clockwork must be adjustable to the declination of the star. The observer bisects the image as soon as it appears and then sets the clockwork going. The thread will now approximately bisect the image during the whole of its transit. It will not do so exactly, because of the unsteadiness of the atmosphere and because of irregularities in the clockwork itself; these the observer must counteract by hand, turning the screw slightly to and fro. This arrangement has been tried by the astronomers at Königsberg, by whom also it was devised. As might be expected, the addition of the clockwork has added to the already great accuracy of the instrument.

It is interesting to note that the registering micrometer with clockwork was proposed as early as 1865 by CARL BRAUN, of Kalocsa, Hungary, but his paper on the subject does not seem to have met with the appreciation it deserved.

II. A NEW SHELTER FOR MERIDIAN INSTRUMENTS.—The registering micrometer is intended to improve Right Ascensions. It is in place here to mention a simple expedient by which it is hoped to get better determinations of the Declinations of stars. The importance of the temperature of the observing-room is attracting more and more attention,* and the desirability of open air observations has been pointed out. Three years ago, with this in view, the International Latitude Observatories (in latitude 39° 8′) were built with roofs which could be rolled entirely away from the instruments beneath. In erecting the new meridian-circle at the Cape of Good Hope, Dr. GILL has gone even further. The shelter for the instrument is of steel, and is built of two entirely separate parts, which meet in the meridian. When ready to observe, the two halves are rolled away from each other (the one east and the other west) by means of a small electric motor, and the instrument is thus left actually in the open air.

III. AUTOMATIC HEATING APPARATUS FOR SPECTROGRAPHS.—Another example in which temperature is of the first importance is afforded by spectroscopic observations for motion in the line of sight. The photographic exposures for this purpose sometimes last an hour or more. If the temperature of the prisms changes much in this time, their indexes of refrac-

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*See, for example, Dr. TOWNLEY'S review of BAUSCHINGER'S "*Untersuchungen über die astronomische Refraction*," in No. 71 of these *Publications*.

tion also change, and consequently the lines in the spectrum become broad and ill-defined. The first to use artificial means to maintain the prisms at a constant temperature was DESLANDRES, of the Meudon Observatory. He inclosed the whole prism-box in a tight compartment and allowed water at a constant temperature to flow through it. A much less cumbersome device was that of LORD, of the McMillin Observatory, Columbus, who was the first to use electric heating. He encased the spectroscope in a wooden box, and so placed a thermometer that its bulb was near the prisms, while its graduated tube projected not only outside of the metallic box containing the prisms, but also outside the outer wooden box. It was not necessary, therefore, to remove the latter in order to read the temperature at the prisms. The wooden box was lined with a quantity of German-silver wire. As this substance is not a good conductor of electricity, it will become slightly heated when a mild current is passed through it. The observer watches the projecting thermometer, and if the temperature falls, he turns on the current long enough to bring it back to its original point. A simple improvement upon this arrangement was made by CAMPBELL. The bulb of the thermometer was placed outside of the prism-box, but still within the wooden box. By controlling the temperature in this region, the prisms themselves will really have a more even temperature than in the former arrangement. The idea of providing a thermostat which would automatically control the temperature of the prisms seems to have suggested itself to several observers. Dr. HARTMANN, has carried out this idea in connection with the new telescope at Potsdam in an especially ingenious manner. Into the open end of a thermometer-tube is inserted a platinum wire so arranged that its end may be set at any desired reading of the temperature scale. Another platinum wire is set permanently into the bulb of the thermometer and is in contact with the mercury. The free ends of these two platinum wires are connected with the opposite poles of a weak electric battery, the circuit also including a small electric magnet. It is clear that there will be a complete circuit only so long as the mercury in the tube remains in contact with the inserted wire,—that is, so long as the temperature does not fall beyond a certain point. When the circuit is broken the magnet releases its armature, and this in turn completes the circuit of the heating current. Thus, as soon as the temperature near the prisms falls, it is at once raised to its original point by the automatic action of the thermostat. Two independent heaters are used,—one on each end of the prism-box,—in order to insure a perfectly uniform temperature of the air surrounding the prisms. The whole spectroscope, including the two thermostats and the two heaters, is, of course, inclosed in a tight wooden box.

IV. WRIGHT'S APPARATUS FOR PHOTOGRAPHING THE COMPARISON SPECTRUM.—The instrument we have just described enables the observer to devote almost all his attention and time to accurate guiding of the telescope. The only interruptions that need be made are for the purpose of photographing a comparison-spectrum (usually the spark-spectrum of iron) in immediate juxtapositon with the star's spectrum. It is generally regarded as desirable to photograph the comparison-spectrum once or twice after the exposure for the star has begun and once or twice before it is quite finished. To do this by the old methods, the observer must stop the exposure on the star, put the sparking apparatus into position, expose the plate to the spark, remove the sparking apparatus and resume the exposure on the star. All this takes considerable time and may possibly disturb the adjustment of the spectroscope: Mr. WRIGHT, of the Lick Observatory, has devised a neat method for introducing the spark-spectrum without stopping the exposure on the star. The middle part of the spectroscope slit is used for admitting the light of the star. On each side of this space is a little prism which reflects the light of a spark placed entirely to one side of the beam of light which comes from the star. Between each prism and its spark a small lens is inserted, so that an image of the spark is formed at the slit, just next to that part which admits the light of the star. In order to photograph the spark-spectrum, the observer simply turns on an electric switch for a few seconds. Mr. WRIGHT'S invention, like the automatic heating apparatus previously described, economizes the observer's time and attention; besides, it lessens the chance of deranging the spectroscope.

V. THE COLOR-SCREEN (for photographing with a visual telescope).—A telescope used for photography must have an objective which is corrected for the blue and violet rays of light, since to these the photographic film is most sensitive. Such a telescope is nearly useless for visual observations, because those rays to which the eye is sensitive, the yellow and the green, are not brought to a focus. On the other hand, a visual telescope (corrected for these latter rays) cannot ordinarily be used for photography. Mr. RITCHEY, of the Yerkes Observatory, has, however, pointed out a simple expedient by which this can be done. Immediately in front of the photographic plate is placed a sheet of plate glass, which is so colored as to be opaque to the blue and violet rays, while allowing the green and yellow to pass through with nearly undiminished intensity. The blue rays are cut out before they can reach the photographic plate, and are not allowed to blur the picture. Furthermore, Mr. RITCHEY uses isochromatic plates (which are much more sensitive to yellow light than ordinary plates), and thus the length of exposure is cut down. Nevertheless, even with isochromatic plates, considerably longer exposures are necessary than if the objective had in the first place been corrected for photography. Mr. RITCHEY has obtained some beautiful large-scale photographs of the Moon and other objects by means of a color-screen and the great visual refractor of the Yerkes Observatory.

VI. THE MEDIAL TELESCOPE.—This is the name applied by the inventor, Professor SCHUPMANN, of Aachen, to a refractor of peculiar construction. The objective of an ordinary refractor consists of two lenses of different densities. This combination is necessary in order to correct for spherical and chromatic aberration. In the medial telescope, however, the objective consists of one lens, and the light which falls upon it passes through uncorrected. Near the eye-piece is placed a somewhat complicated optical system, which not only corrects for spherical and chromatic aberration, but does it better than is possible with the ordinary objective. For, even with two lenses of different densities, it is not possible to correct entirely for chromatic aberration; there is left what opticians call the "secondary spectrum," the effect of which is to make the images somewhat indistinct in even the best of telescopes. With the medial telescope the secondary spectrum is greatly reduced in intensity. A telescope of this description has been built at Urania Observatory, in Berlin; its aperture is thirteen inches and its focal distance is sixteen feet. The secondary spectrum is only one-twentieth as intense as that in an ordinary refractor of these dimensions. It is reported to be of excellent definition and to give surprisingly faultless views of the planets, even under bad atmospheric conditions. By simply turning a small screw, the image of a star may be broadened out into its spectrum with any desired degree of dispersion. The advantages of this instrument are its almost perfect achromatism and its inexpensive construction. Its disadvantages are its small field and the great loss of light which arises from the character of its optical system.

VII. THE STEREOCOMPARATOR.—If we compare two photographs of the same region of the sky,—taken, say, with an interval of half a year,—they will, to all appearances, be counterparts of each other. It is true that each will be somewhat differently distorted by refraction and aberration, and perhaps by a change in the telescope. But all these effects are so small as to be scarcely perceptible, except by exact measurements, besides being gradual and continuous across the area of a plate. It is therefore clear that by comparing two such photographs we may at once detect stars with large parallaxes or large proper motions. Furthermore, if one plate shows an image that on the other plate either does not appear at all, or appears less strongly impressed, we at once suspect that we have to do with a variable or a temporary star.

Many methods for comparing two photographs have been proposed. BARNARD suggested that a *positive* be made of one of them, and that this be put film to film with the other negative. For most stars the black dots on the negative will be covered by the transparent dots on the positive, and those stars for which this coincidence does not occur can be at once detected. PICKERING proposed that one of the plates be exposed with its *glass side* toward the objective of the telescope, and that the other be taken in the ordinary way, with the *film* toward the objective. These may be placed film to film, with the two images of the same star nearly coinciding. Ordinary stars will thus look like double stars of equal components. Variable stars will appear single or of unequal components; and stars of large parallaxes or large proper motions will appear a little more widely double or a little less widely double than other stars. KAPTEYN, in his work for the Cape *Durchmusterung*, faced two ordinary photographs in the same direction, and viewed them through a telescope four and a half feet distant. The further plate was thus seen through the glass and the film of the nearer. TURNER, of Oxford University, proposed that the photographs be projected upon a large screen by means of two stereopticons, so that the images of the same star should nearly coincide. This method, like KAPTEYN'S and the one to be described presently, has the advantage of not requiring specially made photographs: the original negative taken in the usual way may be used.

Some of these methods would appear to leave little to be desired. Yet the instrument used by Dr. WOLF, of Heidelberg, and called by him the *Stereocomparator* is even more convenient than any of these. This instrument is essentially nothing more than a stereoscope, that scientific toy with which we are all familiar. One of the photographs to be compared is viewed solely with one eye, and the other photograph solely with the other eye, in such a manner that the mind gets the impression of a single photograph in which the objects appear at definite distances. The first plate having been fixed in its holder, the second, by proper orientation and tilting, may be so adjusted as to give the stereoscopic effect. Only a limited area of each plate can be observed at a time, but without disturbing their adjustment the two plates may be moved together, so that all the parts of the photographs may be successively brought into view. Most, if not all, of the stars on the photograph will appear to lie in a single plane. But if there be present a star which has been shifted relatively to its neighbors by reason of its parallax or its proper motion, such a star will appear to lie either a little in front or a little behind the plane occupied by the other stars. Again, if a star have a fainter image on one plate than on the other, the eye receives an unpleasant shock, slight but unmistakable. By this means, variable or temporary stars are at once recognized. The scientific value of the stereocomparator may be said to be already proven; with its help Dr. WOLF has found two stars in the *Pleiades* which he suspects of large parallax or proper motions, and he has also published a list of ten suspected variables. The latter are all in *Orion,* which, besides the *Pleiades,* is the only region thus far examined. Incidentally, some novel effects may be obtained with the stereo-comparator. *Jupiter,* for example, may be made to appear much nearer than the fixed stars in the same field, with some of his satellites a little in front and some a little behind *Jupiter* himself.

OBSERVATIONS OF VARIABLE STARS.

By Rose O'Halloran.

The following estimates were made under favorable conditions with a four-inch lens, and may be of interest, though the exact dates of maxima and minima were sometimes unavoidably missed on account of clouds or the interference of high buildings.

S Ursæ Majoris.

A maximum of this long-known variable was predicted for April 18, 1901, but seems to have been a few days later.

1901.	April 4.	Equal to *g* of 9th mag.
	April 8.	Ditto.
	April 16.	Ditto.
	April 18.	About 8.7 mag.
	April 25.	Midway between *g* and *d* of 8th mag.

The comparison-stars used are those lettered on the Harvard charts.

V Coronæ.

In his third catalogue, Professor Chandler alludes to the phases of this variable near its maximum, when a magnitude of from 7.2 to 7.7 is usually attained. A maximum was predicted for April 3, 1901, but observations were not obtained until the following dates:—

1901.	April 8.	Of 9th mag.
	April 16.	Of 10th mag.
	April 18.	Ditto.
	April 21.	Ditto.
	April 23.	Ditto.
	April 25.	Dimmer than 10th mag